

What is claimed is:

(1) An electro-chemical machining apparatus for performing electro-chemical machining on an object to be machined having a metal film on a surface to be machined, said apparatus comprising:

a holding means for holding said object to be machined;

a wiper for wiping said surface of said object to be machined;

a supplying means for supplying electrolytic solution onto said surface of said object to be machined;

a first electrode disposed in a position opposed to said surface to be machined;

a second electrode disposed at a peripheral portion of said surface to be machined; and

a power supply for supplying electrical current between said second electrode of said surface to be machined and said first electrode.

(2) The electro-chemical machining apparatus according to Claim 1, wherein said metal film is a wiring metal film.

(3) The electro-chemical machining apparatus according to Claim 2, wherein said wiring metal film comprises at least one element selected from the group consisting of copper, aluminum, tungsten, gold, silver and any alloy, oxide or nitride of said metals.

(4) The electro-chemical machining apparatus according to Claim 1, wherein said holding means rotates said object to be machined around a rotary axis.

(5) The electro-chemical machining apparatus according to Claim 4, wherein said holding means applies a pressure onto said object to be machined and rotates said object to be machined around said

rotary axis.

(6) The electro-chemical machining apparatus according to Claim 1, further comprising parallel moving means for moving said holding means in parallel with said wiping surface of said wiper.

(7) The electro-chemical machining apparatus according to Claim 1, wherein said wiper comprises a resilient material.

(8) The electro-chemical machining apparatus according to Claim 1, wherein said wiper is provided with venting holes.

(9) The electro-chemical machining apparatus according to Claim 1, further comprising a wiper support member for supporting said wiper, wherein said support member is provided with venting holes.

(10) The electro-chemical machining apparatus according to Claim 1, wherein said wiper is rotatably provided on a rotary axis.

(11) The electro-chemical machining apparatus according to Claim 1, wherein said means for supplying electrolytic solution supplies electrolytic solution including an electrolyte and an additive.

(12) The electro-chemical machining apparatus according to Claim 11, wherein said additive contains copper ions.

(13) The electro-chemical machining apparatus according to Claim 11, wherein said additive contains at least one element selected from the group consisting of a brightener and a chelating agent.

(14) The electro-chemical machining apparatus according to Claim 11, wherein said electrolytic solution contains polishing particles.

(15) The electro-chemical machining apparatus according to Claim 1, wherein said power supply supplies electrical current by applying a repetitive pulse voltage between said surface to be machined and said first electrode.

(16) The electro-chemical machining apparatus according to Claim 15, wherein said power supply supplies electrical current by applying a rectangular pulse, sine wave form, ramp form or PAM form voltage between said surface to be machined and said first electrode.

(17) The electro-chemical machining apparatus according to Claim 1, wherein said power supply supplies variable voltage to change electrical current flowing between said surface to be machined and said first electrode in at least an initial stage and near a final stage of electro-chemical machining.

(18) The electro-chemical machining apparatus according to Claim 17, wherein said power supply sets said electrical current between said surface to be machined and said first electrode to be relatively large in said initial stage of electro-chemical machining and to relatively low in said final stage.

(19) The electro-chemical machining apparatus according to Claim 1, further comprising a temperature adjusting means for adjusting said temperature of said electrolytic solution supplied from said means for supplying electrolytic solution.

(20) The electro-chemical machining apparatus according to Claim 19, wherein said temperature adjusting means adjusts said temperature of said electrolytic solution to 80 °C or lower.

(21) The electro-chemical machining apparatus according to Claim 1, further comprising a reservoir formed to enclose said circumference of said object to be machined for storing electrolytic solution supplied from said means for supplying electrolytic solution.

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(22) The electro-chemical machining apparatus according to Claim 1, wherein said means for supplying electrolytic solution supplies said electrolytic solution to fill said surface of said object to be machined.

10 (23) The electro-chemical machining apparatus according to Claim 1, wherein said means for supplying electrolytic solution comprises an exudation member at an end portion made from a material from which said electrolytic solution exudates, and said electrolytic solution is supplied on said surface of said object to be machined from said  
15 exudation member.

(24) The electro-chemical machining apparatus according to Claim 1, wherein said second electrode is made from a same or nobler metal than said metal film on said surface of said object to be machined.

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(25) The electro-chemical machining apparatus according to Claim 1, wherein said second electrode is disposed to contact said peripheral portion of said object to be machined.

25 (26) The electro-chemical machining apparatus according to Claim 25, wherein said second electrode has a comb-shaped end portion of contact with said periphery of said object to be machined.

(27) The electro-chemical machining apparatus according to Claim  
30 25, wherein said metal film comprises an extending portion extending on said side surface of said object to be machined and said second electrode contacts said peripheral portion of said object to be

machined at said extended portion.

(28) The electro-chemical machining apparatus according to Claim 1, wherein said second electrode is located at said position not contacting said peripheral portion of said object to be machined and said second electrode and said surface of said object to be machined are electrically conducted through said electrolytic solution.

(29) The electro-chemical machining apparatus according to Claim 1, wherein said second electrode comprises a removable cartridge.

(30) The electro-chemical machining apparatus according to Claim 1, wherein a negative voltage is applied to said first electrode and a positive voltage is applied to said second electrode.

(31) The electro-chemical machining apparatus according to Claim 1, wherein said wiper covers said first electrode and an insulation support for supporting said first electrode and is mounted on an end portion of said insulation support.

(32) The electro-chemical machining apparatus according to Claim 31, wherein said wiper is fixed on an end portion of said insulation support by a rubber band or an O-ring.

(33) The electro-chemical machining apparatus according to Claim 1, further comprising a means for changing a distance between a surface of said object to be machined and said first electrode.

(34) The electro-chemical machining apparatus according to Claim 1, further comprising a wiper pressing means for applying pressure to said wiper and a resilient member for transmitting pressure between said insulation support for supporting said first electrode and said

wiper pressing means.

(35) An electro-chemical machining apparatus for performing electro-chemical machining of an object to be machined having a metal film on said surface to be machined, said apparatus comprising:  
a holding means for holding said object to be machined;  
a wiper for wiping said surface of said object to be machined;  
a moving means for causing relative movement of said surface of said object to be machined and said wiper;

a supplying means for supplying electrolytic solution to said surface of said object to be machined;

an electrode movably disposed in a position opposed to said surface of said object to be machined; and

a power supply for supplying electrical current between said surface of said object to be machined and said electrode.

(36) The electro-chemical machining apparatus according to Claim 35, wherein said electrode comprises an anode and a cathode.

(37) The electro-chemical machining apparatus according to Claim 36, wherein each of said anode and said cathode has a ring shape.

(38) The electro-chemical machining apparatus according to Claim 35, wherein said movably disposed electrode comprises a cathode and an anode electrode is further provided to contact said peripheral portion of said surface of said object to be machined.

(39) The electro-chemical machining apparatus according to Claim 35, wherein said electrode comprises a rotatably driven circular shape .

(40) The electro-chemical machining apparatus according to Claim

35, wherein said electrode does not contact with said surface of said object to be machined.

(41) The electro-chemical machining apparatus according to Claim 5 35, wherein said electrode comprises a crescent-moon shape disposed so as to cover at least one portion of a periphery of said object to be machined.

(42) The electro-chemical machining apparatus according to Claim 10 41, wherein said electrode comprises a cathode.

(43) The electro-chemical machining apparatus according to Claim 15 41, wherein said crescent-moon-shaped electrode includes a recessed portion at said circumference fitting to said periphery of said circular wiper and receives one part of said wiper in said recess.

(44) An electro-chemical machining apparatus for performing electro-chemical machining of an object to be machined having a metal film on said surface to be machined, said apparatus comprising:

20 a holding means for holding said object to be machined;  
a wiper for wiping said surface of said object to be machined;  
a moving means for causing relative movement between said surface of said object to be machined and said wiper;

25 a supplying means for supplying electrolytic solution to said surface of said object to be machined;

an electrode movably disposed in a position opposed to said surface of said object to be machined;

a power supply for supplying electrical current between said surface of said object to be machined and said electrode; and

30 a reservoir for storing said electrolytic solution supplied from said means for supplying electrolytic solution, wherein said surface of said object to be machined faces a bottom of said reservoir and

contacts a circumferential portion of said object to be machined.

(45) The electro-chemical machining apparatus according to Claim 44, wherein a contact electrode is disposed at said portion that  
5 contacts said circumferential portion of said object to be machined.

(46) The electro-chemical machining apparatus according to Claim 45, wherein said contacting electrode comprises an anode.

10 (47) The electro-chemical machining apparatus according to Claim 44, wherein said object to be machined is fixed and said wiper rotates while revolving over said surface of said object to be machined.

15 (48) An electro-chemical machining apparatus for performing electro-chemical machining of an object to be machined having a metal film on said surface to be machined, said apparatus comprising:  
a holding means for holding said object to be machined;  
a supplying means for supplying electrolytic solution to said surface of said object to be machined;

20 a first electrode disposed in a position opposed to said surface of said object to be machined;

a second electrode disposed in contact with a peripheral portion of said surface of said object to be machined; and

25 a power supply for supplying electrical current between said surface of said object to be machined and said second electrode.

(49) The electro-chemical machining apparatus according to Claim 48, wherein a voltage is applied to said first electrode and said second electrode from said power supply for performing electrolytic removing  
30 of said metal film from said surface of said object to be machined.

(50) An electro-chemical machining apparatus for performing

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electro-chemical machining of an object to be machined having a metal film on said surface to be machined, said apparatus comprising:

a holding means for holding said object to be machined;

a wiper for wiping said surface of said object to be machined;

5 a moving means for making relative movement of said surface of said object to be machined and said wiper;

a supplying means for supplying electrolytic solution to said surface of said object to be machined;

a mesh electrode covered with said wiper; and

10 a power supply for supplying electrical current between said surface of said object to be machined and said electrode; wherein

said object to be machined is placed on said electrode covered with said wiper for performing electro-chemical machining.

15 (51) The electro-chemical machining apparatus according to Claim 50, wherein said holding means rotates said object to be machined around a rotary axis.

(52) The electro-chemical machining apparatus according to Claim  
20 50, wherein said electrode comprises an anode and a cathode.

(53) The electro-chemical machining apparatus according to Claim 50, wherein said wiper is disposed on a wiper support, a mesh electrode is disposed inside said wiper support and a distance between  
25 said wiper and said surface of said object to be machined is changed through a thickness of said wiper support.

(54) An electro-chemical machining apparatus for performing electro-chemical machining of an object to be machined having a  
30 metal film on said surface to be machined, comprising:

a holding means for holding said object to be machined;

a wiper for wiping said surface of said object to be machined;

a moving means for moving said wiper in a relative direction with respect to said surface of said object to be machined;

a supplying means for supplying electrolytic solution to said surface of said object to be machined;

5 an electrode disposed in a position opposed to said surface of said object to be machined; and

a power supply for supplying electrical current between said surface of said object to be machined and said electrode.

10 (55) The electro-chemical machining apparatus according to Claim 54, wherein said wiper comprises a sheet-like wiper.

(56) The electro-chemical machining apparatus according to Claim 55, wherein said wiper comprises said sheet-like wiper wound in a  
15 roll shape.

(57) The electro-chemical machining apparatus according to Claim 55, wherein said wiper comprises a loop formed by coupling both ends of said sheet-like wiper.

20 (58) The electro-chemical machining apparatus according to Claim 54, wherein a contact electrode is provided to contact with said surface of said object to be machined.

25 (59) The electro-chemical machining apparatus according to Claim 55, wherein said surface of said object to be machined is made to rock on said sheet-like wiper.

(60) The electro-chemical machining apparatus according to Claim  
30 55, wherein said moving means for moving said sheet-like wiper in one direction comprises a plurality of rollers, and some of said rollers are disposed at a constant distance from said surface of said object to

be machined.

(61) The electro-chemical machining apparatus according to Claim 60, wherein said rollers spaced at a constant distance from said surface of said object to be machined comprise an electrode.

(62) The electro-chemical machining apparatus according to Claim 54, wherein said moving means for moving said sheet-like wiper in one direction comprises a plurality of rollers, and some of said rollers are provided with a resilient member for pressing said sheet-like wiper against said surface of said object to be machined.

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